WELL DEVELOPMENT

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1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide an overview of monitor well development practices. The purpose of monitor well development is to ensure removal of fines from the vicinity of the well screen. This allows free flow of water from the formation into the well and also reduces the turbidity of the water during sampling events. The most common well development methods are: surging, jetting, overpumping and bailing.

Surging involves raising and lowering a surge block or surge plunger inside the well. The resulting surging motion forces water into the formation and loosens sediment to be pulled from the formation into the well. Occasionally, sediments must be removed from the well with a sand bailer to prevent sand locking of the surge block. This method may cause the sand pack around the screen to be displaced to a degree that damages its value as a filtering medium. For example, channels or voids may form near the screen if the filter pack sloughs away during surging (Keely and Boateng, 1987).

Jetting involves lowering a small diameter pipe into the well a few feet above the well screen, and injecting water or air through the pipe under pressure so that sediments at the bottom are geysered out of the top of the well. It is important not to jet air or water directly across the screen. This may cause fines in the well to be driven into the entrance of the screen openings, thereby causing blockages.

Overpumping involves pumping at a rate rapid enough to draw the water level in the well as low as possible, and allowing it to recharge. This process is repeated until sediment-free water is produced.

Bailing includes using a simple check-valve bailer to remove water from the well. The bailing method, like other methods, should be repeated until sediment free water is produced. Bailing may be the method of choice in a shallow well or well that recharges slowly.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Development of a well should occur as soon as it is practical after installation, but not sooner than 48 hours after grouting is completed, if a rigorous well development method is being used. If a less rigorous method, such as bailing, is used for development, it may be initiated shortly after installation. The main concern is that the method being used for development does not interfere with allowing the grout to set.

Open the monitoring well, take initial measurements (i.e., head space air monitor readings, water level, well depth, pH, temperature, and specific conductivity) and record results in the site logbook. Develop the well by the appropriate method (i.e., overpumping, jetting, or surging) to accommodate site conditions and project requirements. Continue until the developed water is clear and free of sediments. Containerize all discharge water from known or suspected contaminated areas. Record final measurements in logbook. Decontaminate equipment as appropriate prior to use in the next well.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this (SOP).

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The following interferences or problems may occur during well development:

1. Overpumping is not as vigorous as surging and jetting, and is probably the most desirable method for monitor well development.

2. The possibility of disturbing the filter pack increases with surging and jetting well development methods.

3. The introduction of external water or air by jetting may alter the hydrochemistry of the aquifer.

5.0 EQUIPMENT/APPARATUS

The type of equipment used for well development is dependent on the diameter of the well and the development method. For example, the diameter of most submersible pumps is too large to fit in a two-inch inner diameter (I.D.) well and an inertia pump or other development method should be used.

In general, the well should be developed with the drilling equipment shortly after it is drilled. Most drilling rigs have air compressors or pumps that may be used for the development process.

6.0 REAGENTS

No chemical reagents are used in this procedure; however, decontamination solutions may be necessary. If decontamination of equipment is required at a well, refer to the SOP for Sampling Equipment Decontamination and the site specific work plan.

7.0 PROCEDURES

7.1 Preparation

1. Coordinate site access and obtain keys to the locks.

2. Obtain information on each well to be developed (i.e., drilling, method, well

diameter, depth, screened interval, anticipated contaminations, etc.).

3. Obtain a water level meter, a depth sounder, air monitoring equipment, materials for decontamination, pH and specific conductivity meters, a thermometer, stopwatch, and development equipment/apparatus.

4. Assemble containers for temporary storage of water produced during well development. Containers must be structurally sound, compatible with anticipated contaminants, and easy to manage in the field. The use of truck-mounted tanks may be necessary in some cases; alternately, a portable water treatment unit (i.e., activated carbon) may be used to decontaminate the purge water.

7.2 Operation

Development should be performed as soon as it is practical after the well is installed, but no sooner than 48 hours after grouting is completed. Dispersing agents, acids, or disinfectants should not be used to enhance development of the well.

1. Assemble necessary equipment on a plastic sheet around the well.

2. Record pertinent information in field logbook (personnel, time, location ID, etc.).

3. Open monitor well, take air monitoring reading at the top of casing and breathing zone as appropriate.

4. Measure depth to water and the total depth of the monitoring well.

5. Develop the well until the water is clear and free of sediments. Note the initial color, clarity, and odor of the water.

6. Measure the initial pH, temperature, and specific conductivity of the water and record in logbook.

7. All water produced by development in contaminated or suspected contaminated areas must be containerized or treated. Each container must be clearly labeled with the location ID. Determination of the appropriate disposal method will be based on the first round of analytical results from each well.

8. No water shall be added to the well to assist development without prior approval by appropriate personnel. If a well cannot be cleaned of mud to produce formation water because the aquifer yields insufficient water, small amounts of potable water may be injected to clean up this poorly yielding well. This may be done by dumping in buckets of water. When most of the mud is out, continue development with formation water only. It is essential that at least five times the amount of water injected must be produced back from the well in order to assure that all injected water is removed from the formation.

9. Note the final color, clarity and odor of the water.

10. Measure the final pH, temperature and specific conductance of the water and record in the site logbook.

11. Record the following data in the site logbook:

- Well designation (location ID)
- Date(s) of well installation
- Date(s) and time of well development
- Static water level before and after development
- Quantity of water removed and time of removal
- Type and size/capacity of pump and/or bailer used
- Description of well development techniques used

7.3 Post-Operation

1. Decontaminate all equipment.

2. Store containers of water produced during development in a safe and secure area.

3. After the first round of analytical results have been received, determine and implement the appropriate water disposal method.

8.0 CALCULATIONS

There are no calculations necessary to implement this procedure. However, if it is necessary to calculate the volume of water in the well, utilize the following equation:

$$Well\ volume = \pi r^2 h\ (cf) \quad [Equation\ 1]$$

where:

π	=	pi
r	=	radius of monitoring well (feet)
h	=	height of the water column (feet) [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]
cf	=	conversion factor (gal/ft^3) = 7.48 gal/ft^3 [In this equation, 7.48 gal/ft^3 is the necessary conversion factor.]

Monitor well diameters are typically 2", 3", 4", or 6". Knowing the diameter of the monitor well, there are a number of standard conversion factors which can be used to simplify the equation above.

The volume, in gallons per linear foot, for various standard monitor well diameters can be calculated as follows:

$$V\ (gal/ft) = \pi r^2\ (cf) \quad [Equation\ 2]$$

where:

π	=	pi
r	=	radius of monitoring well (feet)
cf	=	conversion factor (7.48 gal/ft^3)

For example, a two inch diameter well, the volume per linear foot can be calculated as follows:

vol/linear ft	=	nr^2 (cf) [Equation 2]
	=	3.14 (1/12 ft)^2 7.48 gal/ft^3
	=	0.1632 gal/ft

Remember that if you have a two inch diameter, well you must convert this to the radius in feet to be able to use the equation.

The conversion factors for the common size monitor wells are as follows:

Well diameter	2"	3"	4"	6"
Volume (gal/ft)	0.1632	0.3672	0.6528	1.4688

If you utilize the conversation factors above, Equation 1 should be modified as follows:

$$Well\ volume = (h)(cf) \quad [Equation\ 3]$$

where:

h	=	height of water column (feet)
cf	=	the conversion factor calculated from Equation 2

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented in personal/site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety practices.

12.0 REFERENCES

Driscoll, Fletcher G., Groundwater and Wells, 2nd ed., Johnson Division, VOP Inc., St. Paul, Minnesota, 1986, p. 1089

Freeze, Allan R. and John A. Cherry, Groundwater, Prentice-Hall, Inc., Englewood Cliffs, NJ. 1979

Keely, J.F. and Kwasi Boateng, "Monitoring Well Installation, Purging, and Sampling Techniques - Part 1: Conceptualizations", Groundwater V25, No 3, 1987 pp. 300-313.

Keely, J.F. and Kwasi Boateng, "Monitoring Well Installation, Purging, and Sampling Techniques - Part 2: Case Histories", Groundwater V25, No 4, 1987 pp. 427-439.